Information theory for the study of complex physiological systems

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In the emerging field of Network Physiology, the human organism is viewed as an integrated network where the cardiac, circulatory, respiratory, and cerebral systems, each with its own internal dynamics, continuously interact with each other to preserve the overall physiological function. Devising proper analysis frameworks and empirical measures to describe the joint system behavior may yield fundamental insight on the functioning of the networks underlying the regulation of physiological rhythms. In this context, the lecture will introduce an unifying approach for the quantitative description of physiological networks based on the framework of information dynamics. Exploiting known concepts of probability and information theory applied to random processes, the framework defines measures of the information stored, transferred and modified in networks of dynamic systems. After showing approaches for the empirical computation of these measures from time series data, practical applications relevant to Network Physiology will be presented, including the study of the transitions from wake to sleep and across different sleep states in healthy subjects and sleep apnea patients, the analysis of how mental stress alters brain-body interactions, the identification of functional connections within the distributed motor system during postural control, and the detection of spatially distributed brain-heart information transfer during visual emotion elicitation or in epileptic patients.

Spectral Graph Theory and Latent Variable Models in Action: An tutorial in Personality Neuroscience

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With the increasing resolution of brain imaging, the complexity of networks and the need for computational resources also increase, leading to a big data problem. In this tutorial we are going to see how non-linear dimension reduction techniques, such as diffusion mapping, can help us model complex connectivity data. We are going to deploy this analysis in the context of Personality Neuroscience, where our primary aim will be to calculate the common variance across personality traits and functional connectivity. For this purpose rfMRI data from 473 healthy participants were obtained from the Human Connectome Project, and functional connectivity was computed using Pearson correlation. Then their diffusion maps were fed to a latent variable model in order to find the common information between personality and functional connectivity data. In conclusion, the findings suggest a personality/connectivity spectrum where individuals with more conscientious and close-minded traits exhibit higher connectivity within and between specific brain networks, including the limbic, frontoparietal, and default-mode network. Conversely, individuals with less conscientious and more open-minded traits demonstrate increased connectivity within and between the frontoparietal, dorsal attention, and visual networks.

Generating a Data Repository for Cancer Research: the data provider and the technical perspective

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The data provider perspective on the data collection process for creating a federated imaging repository: actions and challenges. The technical perspective on creating a homogenized high quality federated repository.

Functional, structural, and causal cortical mapping of the human brain: Towards the full potential of TMS and beyond

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Transcranial magnetic stimulation (nTMS) is a non-invasive technique to probe cortical excitability. TMS combined with neuronavigation (nTMS) and individual anatomy (MRI) makes motor and speech cortical mapping accurate and reliable for basic research and presurgical clinical evaluation. Moreover, nTMS can be combined with electroencephalography (nTMS-EEG) enabling the adjustment of stimulation parameters based on task-relevant, personalized anatomical, and neurophysiological priors, which results in standardized and reproducible studies across subjects. These advancements in brain stimulation have made nTMS a well-established clinical technique in presurgical evaluation (in motor and speech cortical mapping) and a valuable research tool in studying reactivity and connectivity in major depressive disorder, as well as a promising method for finding biomarkers, e.g., in brain development and neurodegeneration as well. In this talk, I will describe how other advanced neurophysiology and neuroimaging techniques such as magnetoencephalography (MEG), fMRI and real-time diffusion MRI-based tractography can further improve speech cortical nTMS mapping and also demonstrate how structural and functional neuroimaging and EEG can guide nTMS to identify reliable biomarkers for brain disorders. Lastly, it will be shown how these technologically advanced tools can be utilized for the newly designed multi-locus TMS that can lead to automatized brain stimulation protocols.

Exploiting 'Real-World Data (RWD)' - The OHDSI-GR initiative

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The use of IT technologies in health has created new challenges and opportunities that have been emphatically reinforced during the pandemic period. The digital tools developed and the resulting new data pave the way for the transformation of the health system, bringing about a radical change in the way services are provided and accessed and offering multiple benefits to the entire scientific community, health professionals, researchers and ultimately to the patient/citizen.

In this context, the utilization of data collected during clinical practice, often referred to as "Real World Data" (RWD), which come as a result from the ever-increasing use of computer systems (e.g. Electronic Health Records - EHR), creates new potential opportunities. This data, which should be considered as part of the Big Data paradigm, constitute a "gold mine" in terms of evaluating health services, verifying the efficiency and safety of a treatment or a medicine, but also identifying potentially new treatment patterns.

Very often, systematic studies based on such data are referred to as 'Observational Studies', to differentiate them from 'Interventional Studies', in which a specific intervention (e.g., administering drug) in a specific group of patients to analyze its effects.

At the international level, very important initiatives have already been launched such as the Observational Health Data Sciences and Informatics (OHDSI) initiative, for which the Institute of Applied Biosciences of the Center for Research and Technology Hellas (INAB|CERTH) has been appointed as a National Node for Greece. Along these lines, in Europe, a significant network of RWD “providers” (mainly hospitals but also other organizations) with over 160 members funded by the EHDEN program has already been set up.

Information Technologies Institute in Centre for Research & Technology Hellas - - Place to acquire research and development skills in Information Technologies

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The Information Technologies Institute (ITI) is a founding member of the Centre of Research and Technology Hellas (CERTH), and one of the leading Institutions of Greece in the fields of Informatics, Telematics and Telecommunications (a list of all of ITI's research activities can be found here). Since 1998 ITI has participated in a great number of Research and Development projects funded by European, Public investment funds and Services contracted by firms and other private legal entities (a list of ITI's projects can be found here). ITI's research teams show their remarkable scientific work through a number of publications that includes international journals, conferences, books and book chapters (a list of ITI's publications can be found here). In addition, the Institute has the infrastructure, the experience and the maturity to intensify its efforts on diffusing its research activities to key stakeholders and using all the necessary mechanisms and tools towards efficiently bringing novel or improved services and products to them through a number of established spin offs.

Multimedia Knowledge and Social Media Analytics Laboratory - Brain Research and Brain Computer Interfaces

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The use of electroencephalograms (EEG) for conducting Brain Research has been one of the most exciting research fields gaining more and more attention. The potential to tap into the human's brain and understand its secrets carries the promise of improving our lives in many different ways. With the aim to fulfill this promise, MKLab has setup a Lab with highly sophisticated equipment in order to perform research along two related fronts: a) Brain-computer interfaces (BCIs) aiming to make human-computer interaction more natural, especially for people with neuro-muscular disabilities, and b) Brain cognitive processes, investigating brain activation in different experimental scenarios and among different groups for better understanding the underlying cognitive processes.

Real World behavioral and health data from wearable and mobile devices using AI

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A. Delopoulos will present a range of methods and algorithms that produce useful health and behavior indicators on the basis of information captured by sensors embedded in smartphones, smartwatches, smart glasses or earbuds. The advantage of using this type of signals and sensors is that it is discreet and not stigmatizing. Extracted indicators characterize the way individuals move, eat and sleep.

Delopoulos will conclude by summarizing how these new techniques were deployed in recent EU R&D projects related to Obesity, Parkinson's disease and breast cancer post-surgical treatment.

Impact Biomechanics in Crash Simulations

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One of the automotive industry's main goals is to design an advanced protection system ensuring safe and convenient travel for humans. So, numerous virtual crash tests, namely crash simulations, are conducted to examine the level of safety of various dissimilar road users in multiple crash scenarios. The continuous technological progress and the new challenges that Safety engineers have to encounter, e.g., the introduction of "Highly Automated Vehicles" that allows passengers to adopt a broader range of seating choices, as well as the protection of vulnerable road users, such as cyclists, elderly and obese, lead to the necessity of developing innovative crash simulation tools. Human Body Models (HBMs) is a state-of-the-art tool for accurate human modeling, motion reproduction, and potential injury assessment.

This presentation aims to familiarize the audience with the HBMs and present the pioneering research of BETA CAE in Human Body Modeling and Protection. BETA CAE develops practical tools for the biofidelic positioning of HBMs into a wide spectrum of impact scenarios. Moreover, considering the expanding use of two-wheel vehicles and the increased injury risk of obese occupants, BETA CAE focuses on accurately representing and analyzing the kinematic behavior and injury patterns of cyclists and obese users.

Studying multisensory perception and learning via M/EEG

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Multisensory perception was traditionally thought of as a localized process, executed after the completion of each single-modality percept. Newer studies indicate that, instead, it interacts with most neocortical regions, including the ones previously considered as unisensory, dynamically engaging distributed regions in large-scale networks. M/EEG studies constitute the method of choice for studying large scale networks, as the excellent temporal resolution they provide offers unique advantages for the modeling of brain networks over other neuroimaging modalities. In this talk, a series of M/EEG studies approaching multisensory perception, cognition and learning will be presented, portraying both methodological aspects, as well as interpretational challenges.

Introduction to transcriptomics

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In recent years, RNA sequencing (in short RNA-Seq) has become a very widely used technology to analyze the continuously changing cellular transcriptome, i.e. the set of all RNA molecules in one cell or a population of cells. One of the most common aims of RNA-Seq is the profiling of gene expression by identifying genes or molecular pathways that are differentially expressed (DE) between two or more biological conditions. This tutorial will demonstrate a computational workflow for the detection of DE genes and pathways from RNA-Seq data by providing a complete analysis of an RNA-Seq experiment profiling Drosophila cells after the depletion of a regulatory gene.

From Optoacoustics to Thermoacoustics

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Professor G. Sergiadis will present his latest research on new medical imaging modalities.

Optoacoustics is a very well-known physical phenomenon, but which has been only recently used as a biological and medical imaging tool.

Its uniqueness relies on the principle of sending light on a biological tissue and excite it to generate acoustic waves that can be captured by usual ultrasound sensors. The choice of light color and the physical parameters of the excitation offer high specificity and high imaging resolution.

However, light cannot penetrate deeply in tissue, so Radio Frequency fields have also been mobilized to penetrate deeply but also to excite and reveal new imaging parameters and properties.